IDEA-0046-69
Copy 11 of 11

13 JAN 1969

MEMORANDUM FOR: Director of Special Activities

SUBJECT : ESSA Snow Survey Test Program

1. Inquiries have been received through [redacted] requesting the Office of Special Activities to assist the Environmental Science Services Administration, Department of Commerce (ESSA) in a study program aimed at investigating the usefulness of low-resolution satellite photography in the assessment of snow cover. Such assessment is needed in many areas (e.g., California) for determination of the projected spring run-off and related water resource management problems. 25X1A

2. The principal request is for periodic coverage of three regions of the Sierra Nevada Range, in east-central California, in the spring of 1969. Coverage is desired at weekly intervals (preferably), or at least once per month. Resolution better than 100 feet, in black-and-white or color, is needed. All processing and analysis, subsequent to the processing of the original negatives, would be accomplished by ESSA.

3. The area desired is about 50 miles wide, and consists of three watershed basins within the Sierras, extending about 300 miles (from the southern edge of the southern basin to the northern edge of the northern basin), starting about 50 miles north of Edwards Air Force Base. (See Attachment I).

4. The basic required coverage could be best accomplished with the T-35 Light-weight Tracker Camera (Standard Tracker Camera in both the U-2C and the U-2R). Details on this camera are given in Attachment II. Either aircraft could be used for these missions. Nadir resolution of this camera system, using Type 3404 fine-grain panchromatic black and white film is about 18 feet, degrading to about 50 feet at 20 nautical miles off nadir. Resolution on Type SO 121, normal color film, or [redacted] 25X1D
is 35 feet (nadir) and 100 feet at 20 miles off nadir (these

values are all for an altitude of 70,000 feet.) Swath width would be somewhat decreased, and nadir resolution improved, by the higher terrain values (estimated at 5000 to 12,000 feet, for regions of significance).

5. A single pass over the area of interest would probably accomplish most of the desired photography; two parallel flight paths, separated by about 25 miles would give excellent coverage. With the short flight times involved, and nearness to the operating base, the flights could be accomplished as secondary missions with normal flight routines. No special Q-bay, etc., installations are needed, as the tracker camera is a routine equipment.

6. Weather: Climatology studies of the area of interest have been published by ESSA, (Attachment III) showing that, during the period of interest, generally 3 - 6 days of 1/10 or less cloud cover prevail per month. (Our normal reconnaissance requirement is CAT II: 2/8 or less.) Access to detailed station reporting should allow accurate pre-flight assessment of the weather situation. An alternate approach, considering the short flight lines required, and the lack of special equipment, is to make this flight line a frequently programmed addition to normal test/training missions, and to supply to ESSA only those flights which were accomplished in relatively good weather. If all flights were submitted, ESSA would have a good basis for estimation of cloud cover requirements.

7. Other Camera Systems: While the tracker camera will apparently supply the basic information needed, it is suggested that one flight with the IRIS II be programmed for delivery to ESSA, for comparative studies and confidence check. Similarly, one flight with the A-1 Tri-metregon system (similar to systems common to the mapping community) would provide an added level of confidence to the system study.

8. Suggested Program: During the period 3 March 1969 to 30 May 1969, one flight per week to be programmed with approach to a departure from the EAFB area be over the Sierra Nevada range, with the tracker camera operating. (Generally these would be at the end of this test/training
25X1D mission.) Altitude to be 70,000 feet [redacted] (pressure 25X1D
altitude). Fifty percent of these flights shall be with Type 3404 in the tracker, 25% with Type SO 121, and 25% with [redacted] At least one flight per month, within 4 days of

the first of each month, shall be at Category II weather or better, over one of the specifically delineated areas, if possible. The resultant photography shall be considered unclassified; resultant photography shall be edited, and only that portion pertaining to the study effort shall be supplied to ESSA. One duplicate positive, unclassified, shall be supplied within a week; the original negative clips may be delivered to ESSA when no longer needed for project purposes. When available, unclassified film from main camera will be made available. It is assumed that this OSA effort can be accomplished at no cost to ESSA.

9. Actions needed:

a. Review with ESSA of the proposed technical program.

b. Exact delineation of the areas of interest.

c. Establishment of points of contact, delivery mechanisms, auxiliary data needed by users, etc.

d. Requirements for test plan to Detachment G.

[redacted]

25X1A

A(T)D/R&D/OSA

Attachments: (3)
As stated

25X1A

A(T)D/R&D/OSA/[redacted]:anw/13 Jan 1969
Distribution:
Copy 1 - D/SA
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8 - SSD/R&D/OSA
9 - A(T)D/R&D/OSA
10 - Chrono
11 - RB/OSA

TABLE I

T-35 PANORAMIC TRACKING CAMERA SYSTEM PARAMETERS

Lens	50-mm, f/2.3 6-element Baltar EFL 50.0 ± 1.0 mm
Filters	1) Red-Wratten 25A 2) Minus Blue-Wratten 12 3) Clear-Wratten 1A
Coverage	28 x 180 degrees
Format	1.00 x 6.18 inches
Scan Rate	2π radians/sec (1/2 sec for 180° scan)
Interval	30 seconds
Film Supply	700 feet, 35mm thin base, non-perforated
Resolution	80 lines per mm on EK 3404
Power Required	28 VDC, 1/2 amp,(transient to 4 amp)
Weight	12 lbs loaded
Size	15 x 12 x 4 inches
Data	Time of start of scan and frame count at edges of format at nadir.

SECTION I

DESCRIPTION

1. GENERAL

The T-35 Panoramic Tracking Camera, shown in Figure 1, is a compact, lightweight, high-resolution, aerial camera, which carries 700 feet of 35 millimeter, thin-base, non-perforated film. Incorporating a newly developed scanning system of parallel plane-mirrors, the camera produces successive, overlapping, 180-degree panoramic photographs. The sequence interval is automatically controlled by a preset clock movement, the dial of which is recorded at the edge of each frame as part of the total information content.

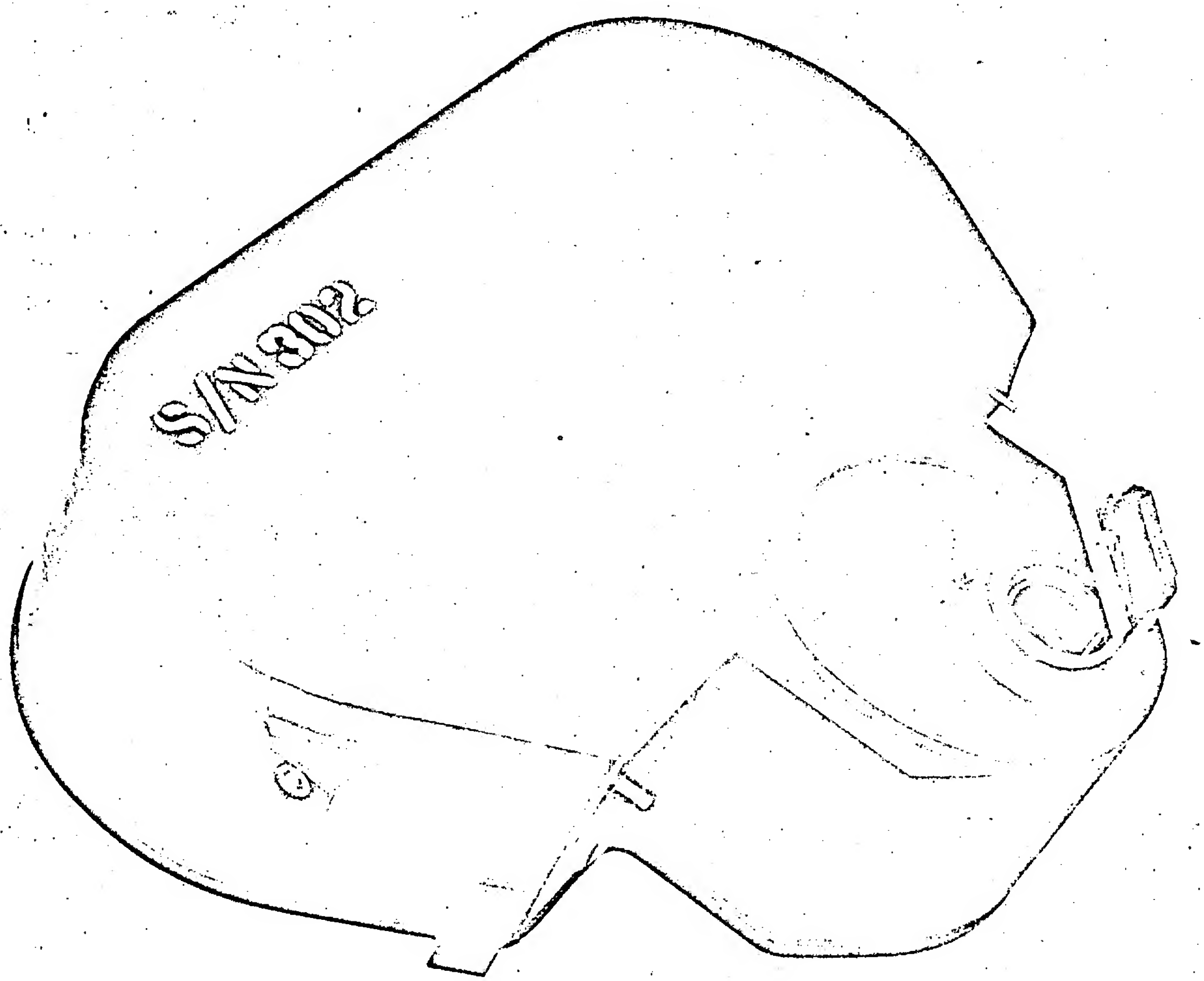


Figure 1. T-35 Panoramic Tracking Camera

Designed for portability and small-area installation, the camera weighs twelve pounds fully loaded and is four-inches thick; moreover, it is completely self-contained and operates on 28-volt DC power. The electrical control network is constructed on a modular basis; the entire harness and associated switches are replaceable in minutes.

2. FIELD SCANNING AND RESOLUTION

Successive scans of the 180-degree field are projected through a focal-plane slit onto the film by the optical system. An external mirror is utilized to scan a 180-degree field, transverse to the direction of flight. (See Figure 2.) The film is stationary while the external and internal mirrors, lens, and slit rotate as a unit.

Resolution of the order of 80 lines per millimeter and greater is realized. This performance is possible because the optical system is such that the lens effectively rotates about its second nodal point during the 180-degree scan; hence, there is no image motion and the film remains stationary during scanning. Resolution losses associated with image/film synchronization are thereby eliminated.

3. DATA RECORDING AND FILM FORMAT

A data chamber containing a clock (Accutron) and a digital counter is incorporated in the camera. An image of the clock dial and counter is recorded at the edge of the film at the nadir position during each exposure. The film format is shown in Figure 3.

4. SYSTEM PARAMETERS AND OPERATIONAL CHARACTERISTICS

System parameters for the T-35 Panoramic Tracking Camera are given in Table I. The operational characteristics of the camera are graphically illustrated in Figures 4, 5, and 6. These illustrations show: (1) ground resolution versus altitude at 80 lines per millimeter, (2) overlap versus V/H at a 30-second interval, and (3) nadir ground coverage versus altitude, respectively.

5. SEQUENCE OF ACTIONS (MECHANICAL)

The mechanical actions that occur during a cycle of operation are described below. Major components are identified in Figures 7 and 8.

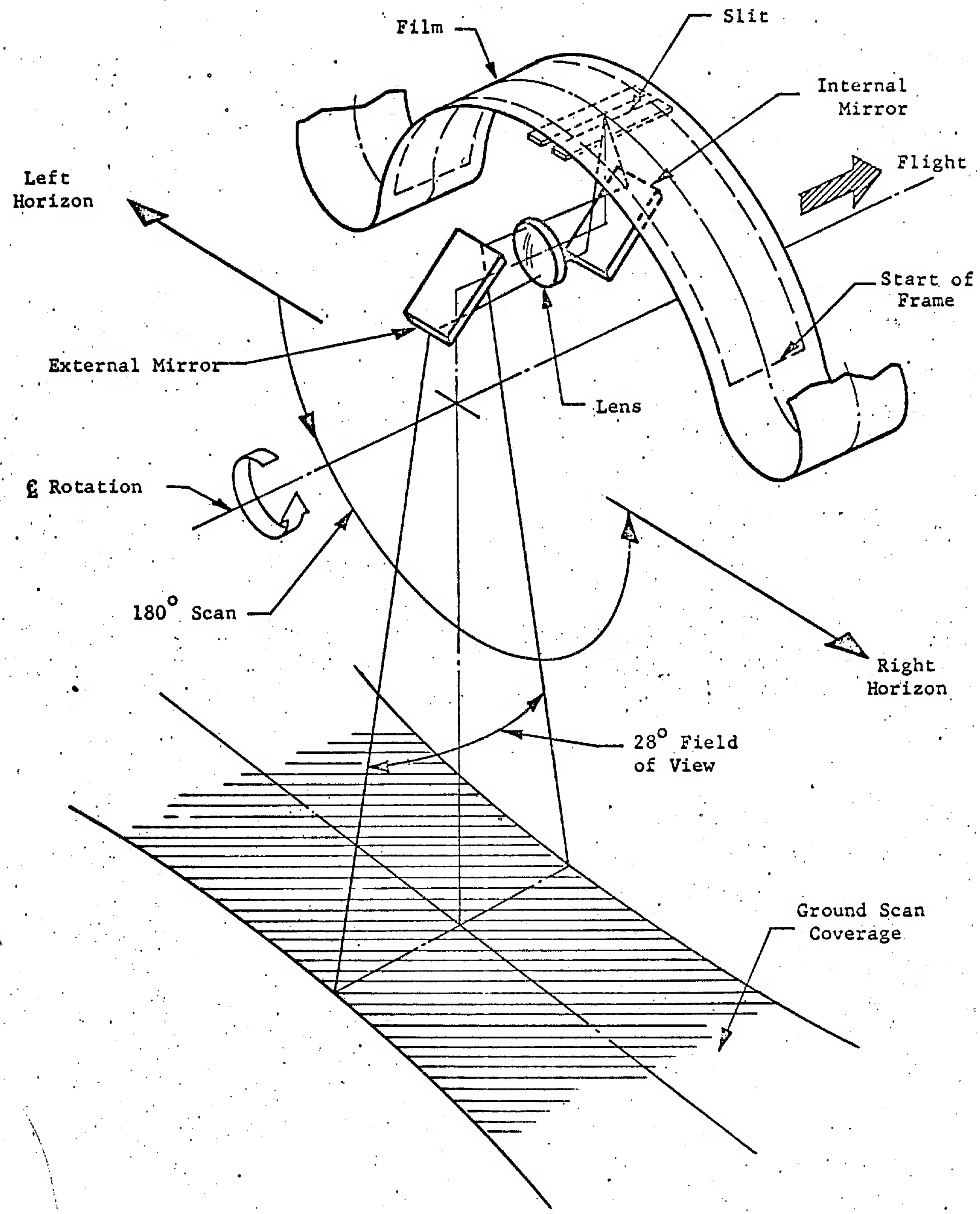


Figure 2. Optical Path at Nadir Position

Along Track @60°
Cross Trac. @60°

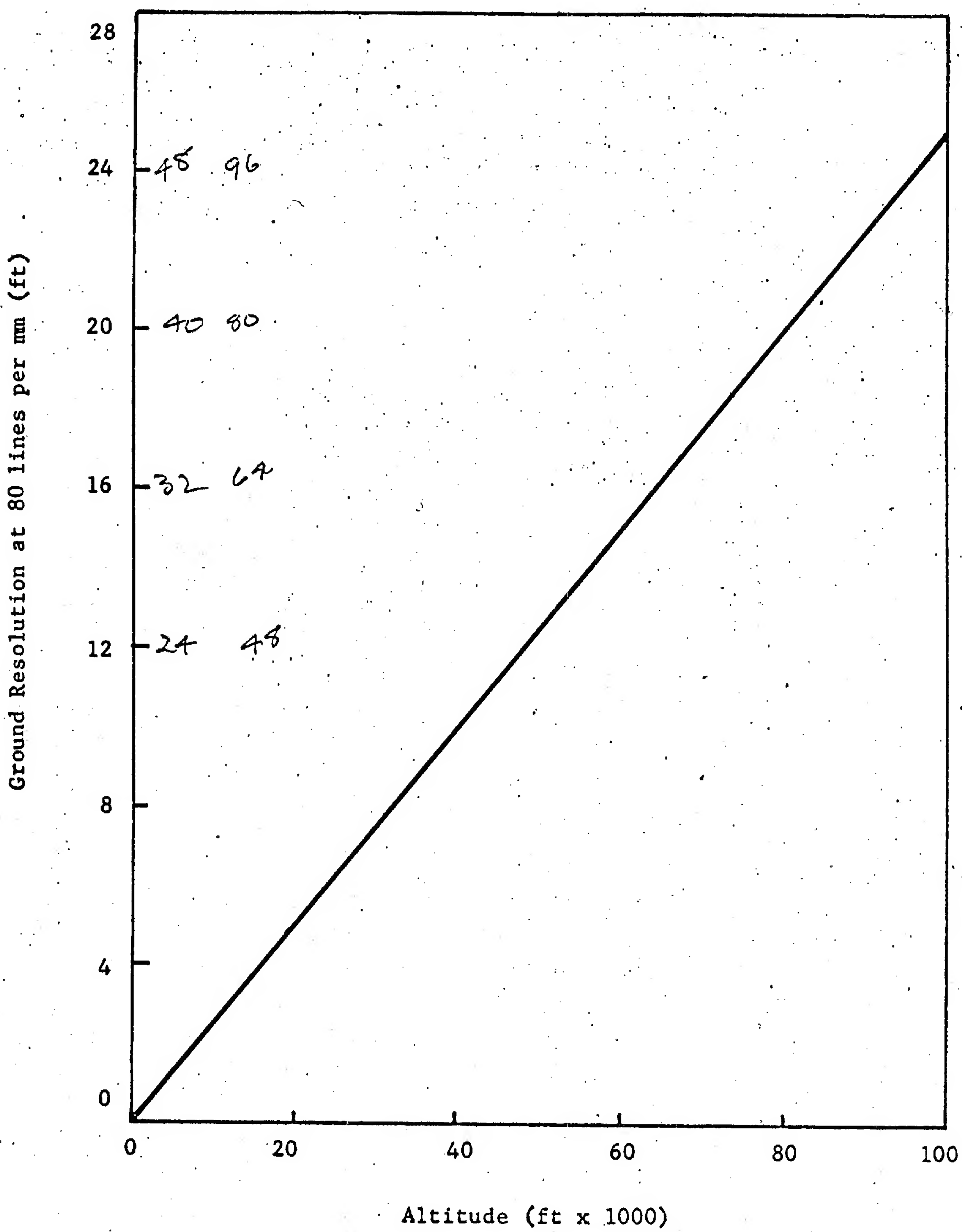


Figure 4. Ground Resolution Versus Altitude (at 80 lines per millimeter)

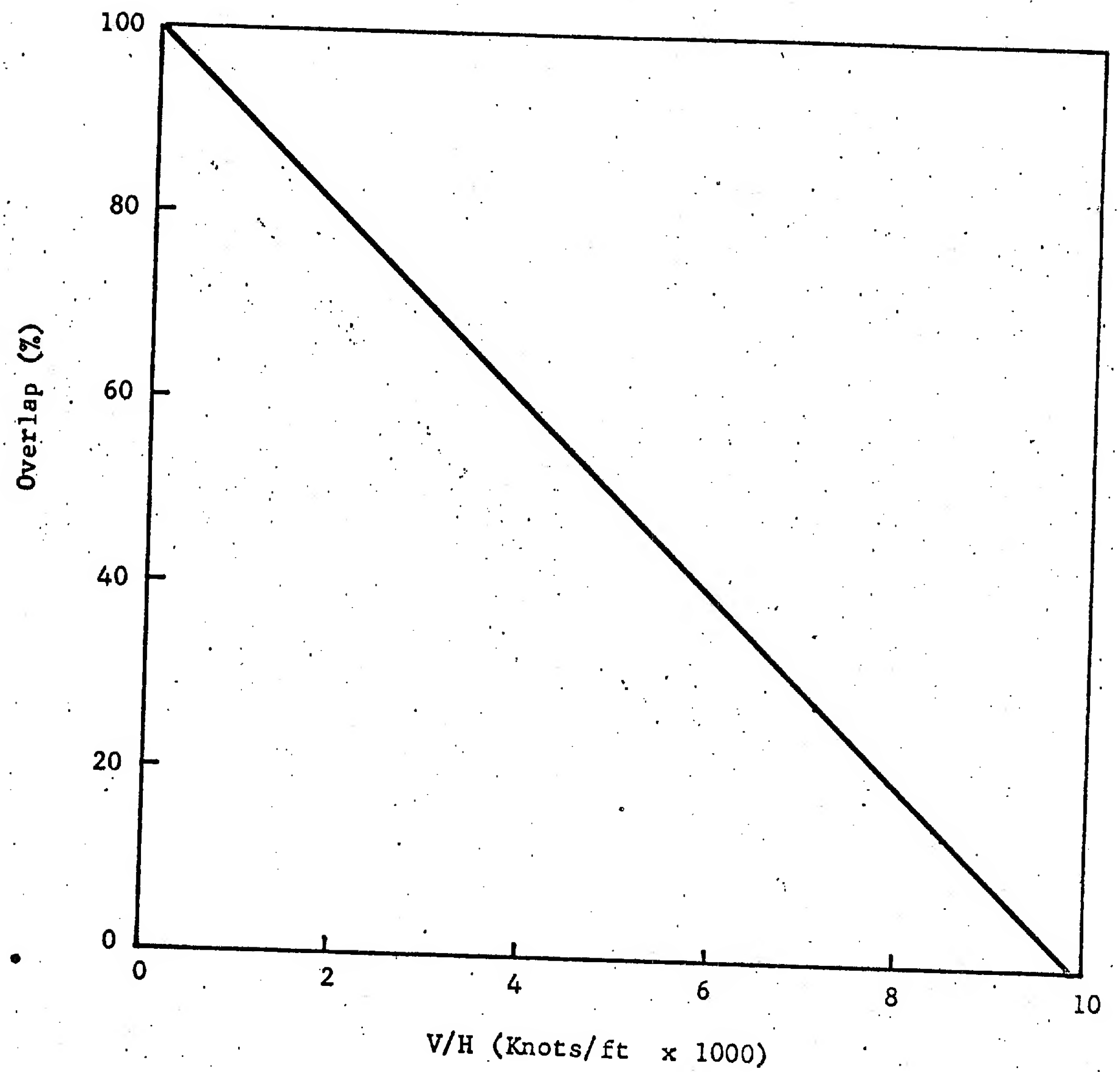


Figure 5. Overlap Versus V/H at 30 Second Intervals

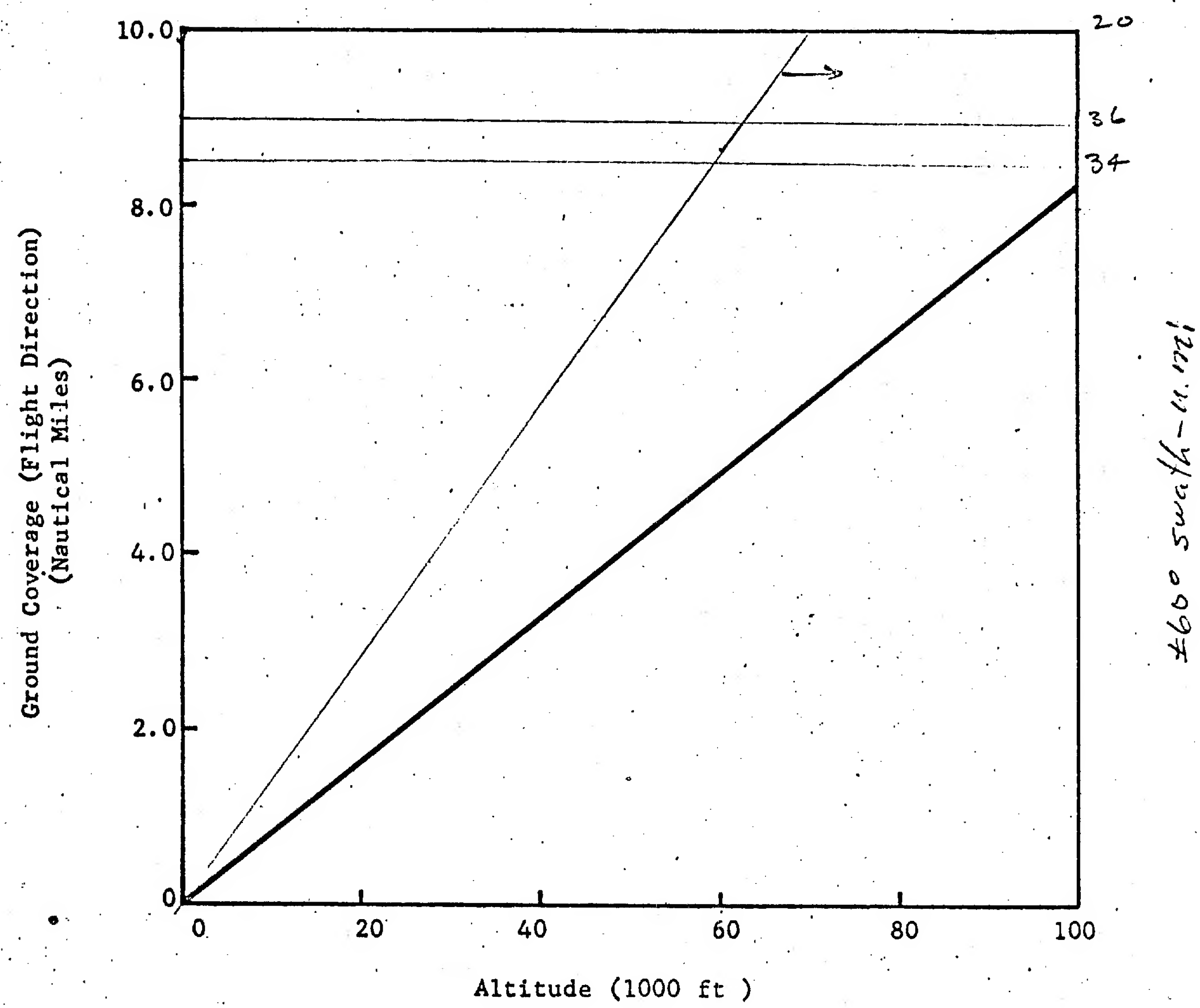
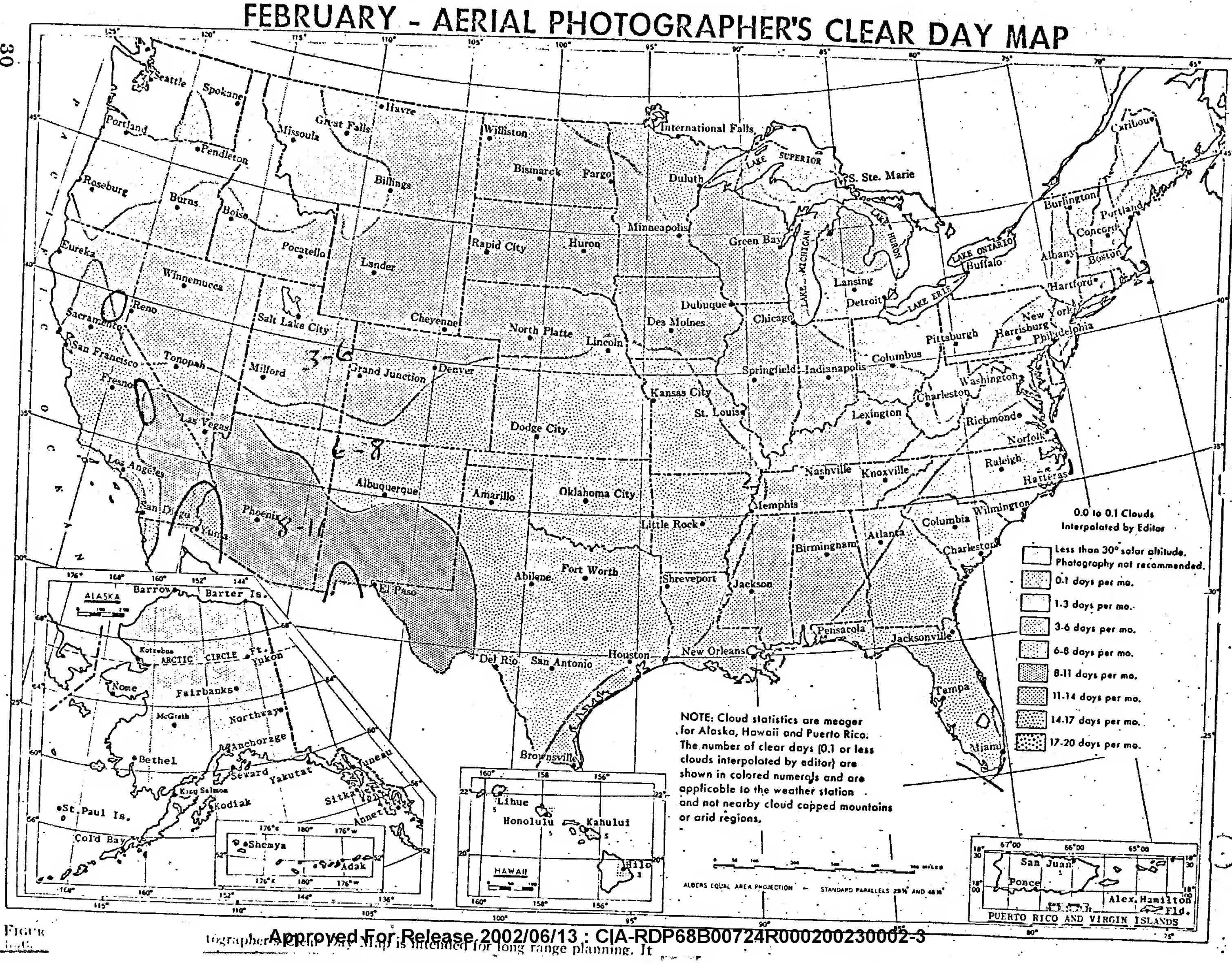


Figure 6. Nadir Ground Coverage Versus Altitude

FEBRUARY - AERIAL PHOTOGRAPHER'S CLEAR DAY MAP



FIGURE

tographer's Clear Day Map is intended for long range planning. It

MARCH - AERIAL P...OTOGRAPHER'S CLEAR DAY MAP

... Aerial Photographer's Clear Day Map is intended for long range planning. It ... number of clear days that can be expected from sunrise to sunset that meet the ... solar altitude requirement for aerial photography. ... ter 2 for a more

APRIL - AERIAL PHOTOGRAPHER'S CLEAR DAY MAP

Figure 2.1.11--The Aerial Photographer's Clear Day Map is intended for long range planning. It indicates the number of clear days that can be expected from sunrise to sunset that meet the minimum 30 degree solar altitude requirement for aerial photography. The ... altitude ...

MAY - AERIAL PHOTOGRAPHER'S CLEAR DAY MAP

Figure 2 ... indicates ... minimum 30 ... altitude on th... precise sola... ...al Photographer's Clear Day Map is intended for long range planning. It ...of clear days that can be expected from sunrise to sunset that meet the ...ar altitude requirement for aerial photography. The delineation of 30° solar ...of maps is only approximate; refer to Chapter 2 Sub-Chapter 2 for a more ... of U. S.

PROPOSAL (Environmental Sciences Group, NESC)

Background of Proposal:

>50 percent of water resources in the 17 western states of the contiguous United States is received from mountain snow cover. Estimates of this snow cover strongly affect the management of stored water and its use for power, pollution and irrigation. Present day hydrologists must make this snow cover estimate with inadequate data. Ground values are generally too sparse because of inaccessability and because reliable remote ground sensors have not been available. Aerial reconnaissance is generally too expensive because of the area involved and flight scheduling difficulties due to frequent inclement weather. And finally, present weather-satellite data have far poorer resolution than that desired by hydrologists. Resolution of 100 feet, a requirement stated by some hydrologists and easily achieved by low-flying aircraft, is unobtainable by satellites because of huge information storage, retrieval, and interpretation requirements.

Thus the hydrologist is being asked what is the next-to-minimum resolution needed to resolve various features that they need to see from satellites. There having been no systematic collection of correlative ground snow data together with suitable observation from aloft, all estimates made to date are based on basic optic and/or electronic ability. It is known from use of ESSA satellite data that the areal extent of mountainous snow cover can be determined more precisely than the two-mile resolution that is inferred from consideration of the camera optics and electronics of the video sensor system alone. This increase in effective resolution is due

to topographical recognition, that is, to the tendency for the snow line to follow contour lines. Additional recognition can ~~also~~ be obtained by the loss of distinguishing terrestrial features in going from no snow to snow cover conditions. It is the lack of knowledge about the effects of reduced resolution on snow mapping, especially when imagery is combined with limited ground observations, that hampers the hydrologist in stating minimum satellite sensor requirements.

4. Date: 12 10 68

11. Title: High-Altitude Snow-Cover Mapping

19. Gov't. Lab: ESSA
NESC
Washington, D.C. 20233
Baker, D. R.

STATOTHR [redacted]

20. Performing Organization: ESSA
NESC
Wash., D.C. 20233
Baker, D. R.
[redacted] STATOTHR

24. Technical Objective: To use a high-flying aircraft to gather photographic data for determining the image resolution needed for mapping mountainous areal snow cover. For maximum benefit the flights must be over areas where there is a dense network of correlative ~~surface~~ ground values. Also the flights should be made at a time which is most beneficial to those making estimates of snow cover.

25. Approach: There are three basins in California's Sierra Nevada Mountains that should be considered for this experiment. They are, in order of priority:

1. American River Basin
2. Kings River Basin
3. Upper Kern River Basin

The American River basin (insofar as known in the U.S.) has the most instrumentation and the greatest observation frequency for determining snow cover, volume and water content, of any place in the world.

The periods having the highest priority for these flights would be, in order of priority:

1. April 1 thru May 1
2. After May 1 to June 1
3. After March 1 to April 1

Climatological records indicate maximum snow depth for the Sierra Nevada Mountains occurs near the middle of March, that the snow melt usually begins in April, and that the snow pack is essentially gone by the end of May.

The frequency of observation hydrologists desire is once a week. "Ground truth" values of this frequency on a basin-wide basis are obtainable only from the American River basin. The frequency having second priority is once a month near the first of the month, with 4 days on either side of the first considered as being on the first. Correlative ground values of this frequency are obtainable from any of the basins listed.

Although black and white photographs should be adequate, color or multispectral coverage would be highly desirable in view of the need for more knowledge on what is the best and most economical sensing technique.

The photographs, after processing, will be duplicated. One set will be used to determine the areal snow cover and its relationship to that obtained from correlative ground values and from satellite pictures. The second set will be used to degrade the resolution by photographic means until a useable minimum resolution is determined.

Coordination:

Flights:

Analysis:

Snow areal cover - Hydrologist in Charge
River Forecast Center
Sacramento, California

Degradation of Resolution - C&GS

Weather for flights: HIC, RFC Sacramento

Technical Advisors:

Hydrology: D. R. Baker
Photogrammetry: E. H. Ramey